CONFIDENTIAL

INTERIM ENGINEERING REPORT

ON

TRANSMITTER-RECEIVER PROJECT

ASSIGNED [redacted] 50X1

REPORT NO. 8

COVERING THE PERIOD

NOV. 1, 1953 TO DEC. 31, 1953

[redacted] 50X1

CONFIDENTIAL

SECTION I

PURPOSE OF PROJECT

The general purpose of this project is to investigate and develop transistor circuitry for use in transmitter-receiver equipment [redacted] 50X1 [redacted] 50X1 Specifically, the object is to determine the electrical characteristics of suitable types of transistors, to propose new types of transistors with desirable electrical characteristics for the transmitter-receiver, and to determine the most practical overall circuit configuration for the transmitter-receiver using transistors wherever possible.

SECTION II

PROJECT STATUS

Means of stabilizing the operating point of junction transistors have been achieved. Electrical characteristics and noise figure have been measured on available transistors. Life tests have been made. Specific circuits including oscillators, mixers, audio amplifiers, i-f amplifiers, and r-f amplifiers have been studied. A breadboard radio receiver (3 to 6 mc) has been built. High-frequency equivalent circuits for junction transistors have been evolved. A 2 to 8-mc prototype receiver is being built.

SECTION III

SUMMARY OF PROGRESS THIS PERIOD

(November-December 1953)

A. Construction and testing of two tuners were completed.

B. Preliminary tests of a 2-8 mc breadboard receiver using tuner #1 have been made and circuits modified.

C. Construction of a prototype receiver using tuner #2 is 90% complete.

SECTION IV

DETAILS OF WORK DONE THIS PERIOD

A. TUNER CONSTRUCTION AND TESTING

Two complete tuners have been constructed. Tuner #1 has been used and tested in the breadboard receiver while tuner #2 is being incorporated in the receiver model. Similar coil designs are used in both tuners, but 1-1/4" long cores are used in the #2 tuner while 1" long cores are used for #1 tuner. Comparing the coil data (Table 1) for both tuners, one can see that both the Q of the coils and the frequency coverage at both bands have been improved in tuner #2.

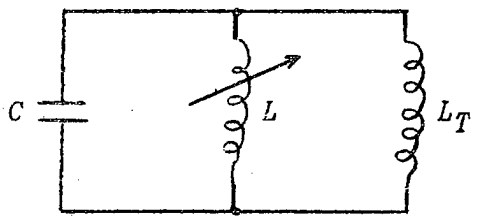
B. PRELIMINARY TESTS OF BREADBOARD 2-8 MC TUNABLE RECEIVER

A breadboard 2-8 mc tunable receiver using tuner #1 has been tested and the circuit modified as shown in Figure 1. Circuit modifications and the results of preliminary performance tests will be described briefly as follows. In general, the performance of this breadboard model receiver meets the specifications.

1. *TRACKING COIL DESIGN AND TRACKING CURVE*

A shunt-inductance tracking circuit is used in the oscillator. The value L_T of the shunt tracking coil required is calculated from the relation:

$$\frac{\dfrac{L_1 L_T}{L_1 + L_T}}{\dfrac{L_2 L_T}{L_2 + L_T}} = \left(\frac{f_2}{f_1}\right)^2$$



where f_1 = min. frequency of resonance (mc).

L_2 = value of L required to resonate with L_T and C at f_1 (μh).

TABLE I--TUNER COIL DATA

(All data taken with coils in the tuner)

f_{max} - max. frequency of operation of coil.

C_{max} - capacitance required to resonate coil with core out at f_{max}.

Q_m - Q of coil at f_{max}.

f_{min} - min. resonant frequency obtainable with coil with core in the coil and resonant with C_{max}.

frequency ratio = $\frac{f_{max}}{f_{min}}$

	TUNER #1					TUNER #2				
	f_{max} mc	C_{max} $\mu\mu f$	Q_m	f_{min} mc	$\frac{f_{max}}{f_{min}}$	f_{max} mc	C_{max} $\mu\mu f$	Q_m	f_{min} mc	$\frac{f_{max}}{f_{min}}$
HIGH FREQUENCY COILS										
OSCILLATOR	8	135.4	65.5	3.80	2.11	8	134.2	75	3.63	2.20
ANTENNA COUPLER	8	140.2	62.5	3.63	2.20	8	134.0	72	3.74	2.14
R-F INTERSTAGE COUPLER #1	8	136.8	60.5	3.77	2.12	8	134	70	3.62	2.21
R-F INTERSTAGE COUPLER #2	8	130	63	3.75	2.13	8	132.1	73	3.68	2.17
LOW FREQUENCY COILS										
OSCILLATOR	4	132.3	62.5	1.93	2.07	4	136.7	75	1.86	2.15
ANTENNA COUPLER	4	129.7	71.0	1.93	2.07	4	141.0	78	1.87	2.14
R-F INTERSTAGE #1	4	128.0	71.0	1.95	2.05	4	139.5	76	1.89	2.12
R-F INTERSTAGE #2	4	133.3	71.0	1.92	2.08	4	138.7	80	1.82	2.20

f_2 = max. frequency of resonance (mc).

L_2 = value of L required to resonate with L_T and C at f_2 (μh).

For the high-frequency coil, we have

f_1 = 4.455 mc $\qquad$ L_1 = 12 μh

f_2 = 8.455 mc $\qquad$ L_2 = 3 μh

Therefore,

L_T = 78 μh

C = 120 $\mu\mu$h

and, for the low frequency coil,

f_1 = 2.455 mc $\qquad$ L_1 = 48 μh

f_2 = 4.455 mc $\qquad$ L_2 = 12 μh

Therefore, L_T = 158 μh

C = 112 $\mu\mu$f

A calibration curve for the high band of the receiver has been obtained as shown in Figure 2. The travel of the tuner is measured in terms of revolution of the tuner shaft (32 revolutions of the tuner shaft is evuivalent to one inch linear travel of the tuner). The linearity is expected to be improved by using tuner #2.

2. *OSCILLATOR INJECTION VOLTAGE*

Data on oscillator injection voltage to the mixer vs frequency (using the high-frequency-band oscillator of tuner #1) is plotted as Figure 3. Results show that a variation of oscillator injection voltage from 160 mv to 500 mv has been obtained as frequency varies from 4 to 8 mc. This range of magnitude of the injection voltage lies in the reasonable working range where approximately constant conversion gain can be obtained from the mixer (see Report #2 on the transistor mixer). The secondary winding of the high-frequency oscillator coil consists of 7-1/2 turns, evenly spaced between the primary coils, while the low-frequency oscillator coil has 15 turns.

3. *AGC PERFORMANCE*

Among various methods of applying AGC to the receiver, the method shown in the schematic diagram (Figure 1) best meets the required performance.

Figure 4 shows the different AGC characteristics that may be obtained. Curve 1 shows the response of audio output versus the r-f input voltage for AGC applied to the first i-f amplifier only. Curves 2, 3, and 4 show the effect of applying AGC to the first and second i-f amplifier simultaneously. A 3-db maximum audio output variation can be obtained for the required variation of input signal from 15 μv to 10 mv by using the AGC system with R_{d1} = 120 ohms and R_{d2} = 50 ohms (curve 4).

4. *PERFORMANCE OF THE RECEIVER*

The following data was obtained in the first tests:

Sensitivity - 15 μv input at 4 mc with a 16 db signal-to-noise ratio. Signal modulated 30% with 400 cycles. 5 mw audio output.

Selectivity - 6-db bandwidth is 13 KC.

60-db bandwidth is 90 KC.

Image Rejection - Better than 40 db (2-8 mc).

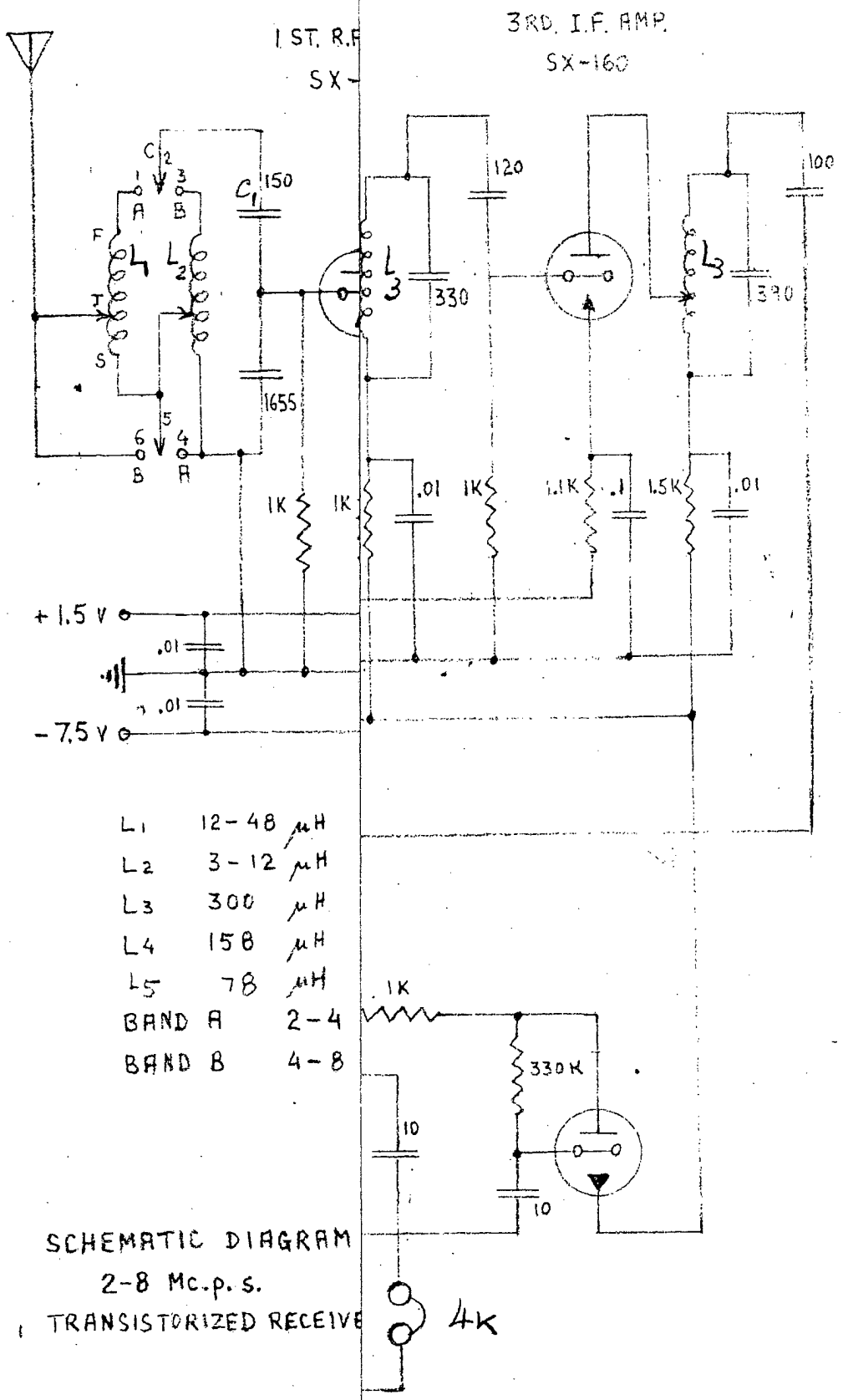


Fig (1) SCHEMATIC DIAGRAM
2-8 Mc.p.s.
TRANSISTORIZED RECEIVE

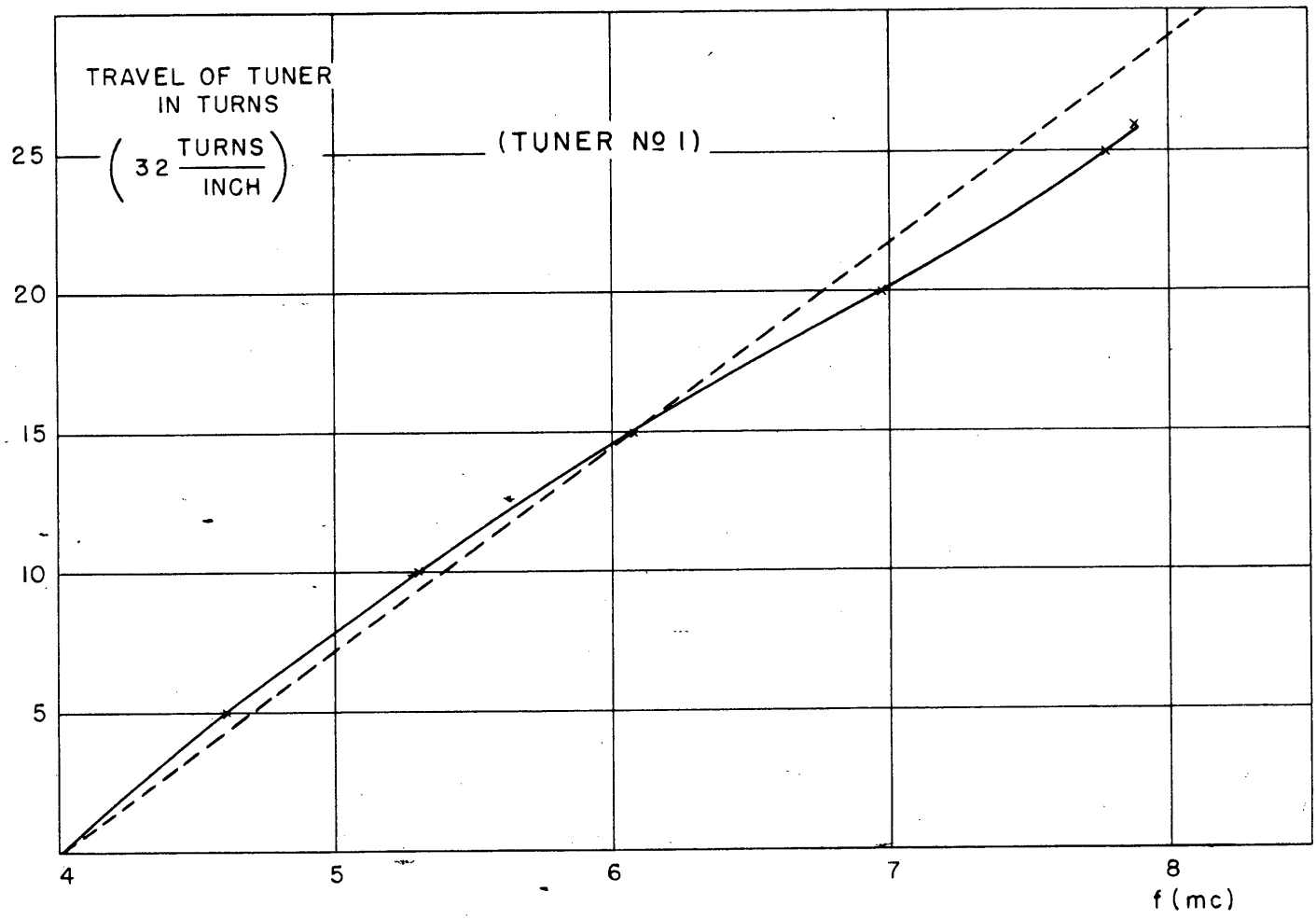


FIG. (2) TUNING CURVE OF HIGH-BAND OF 2-8mc RECEIVER

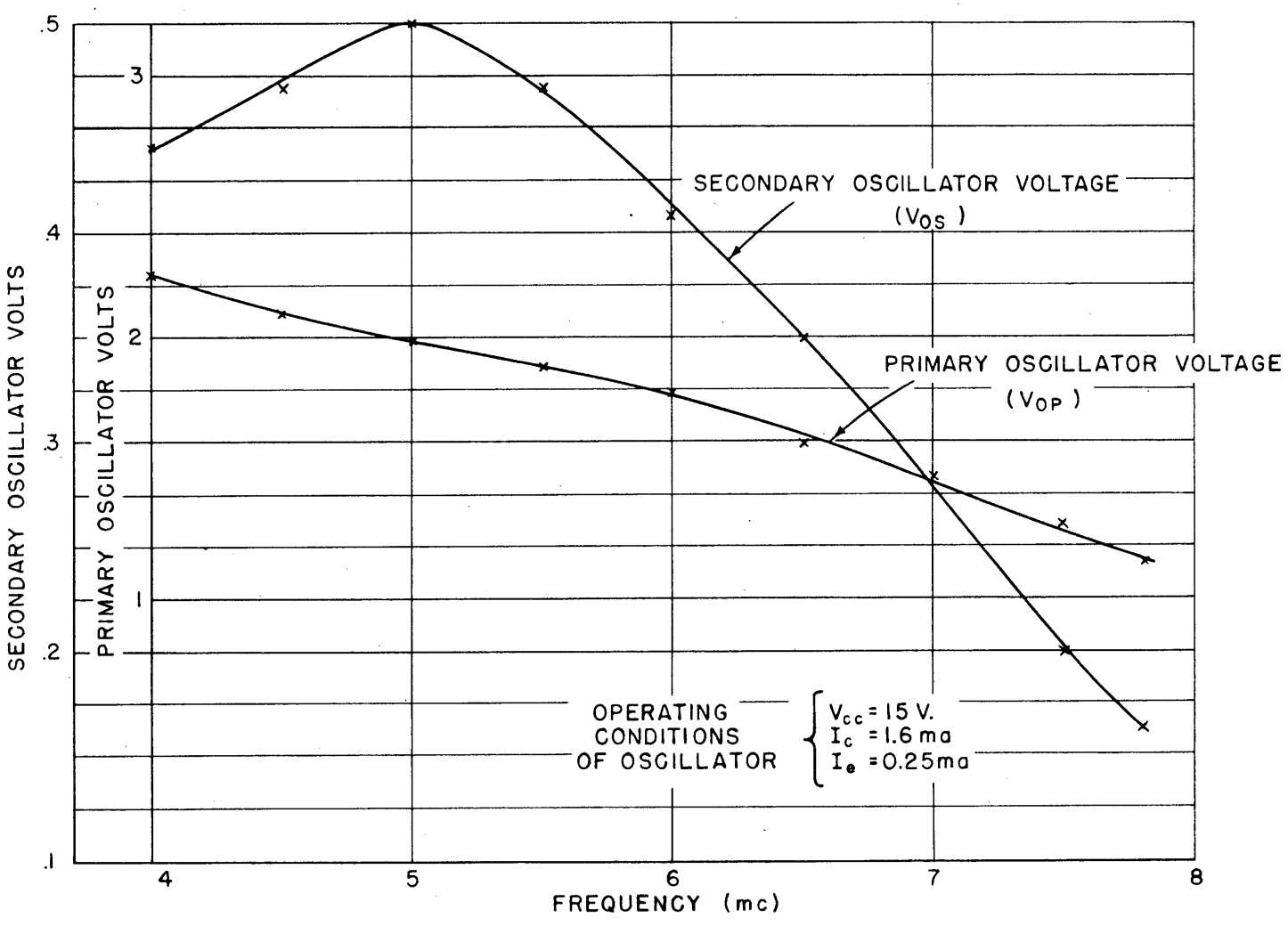
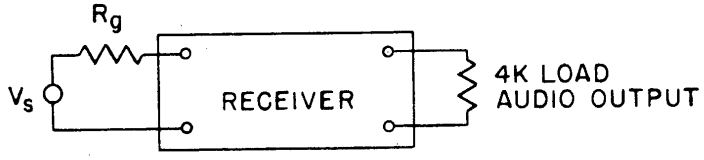


FIG. 3 HIGH FREQUENCY OSCILLATOR INJECTION VOLTAGE VS FREQUENCY



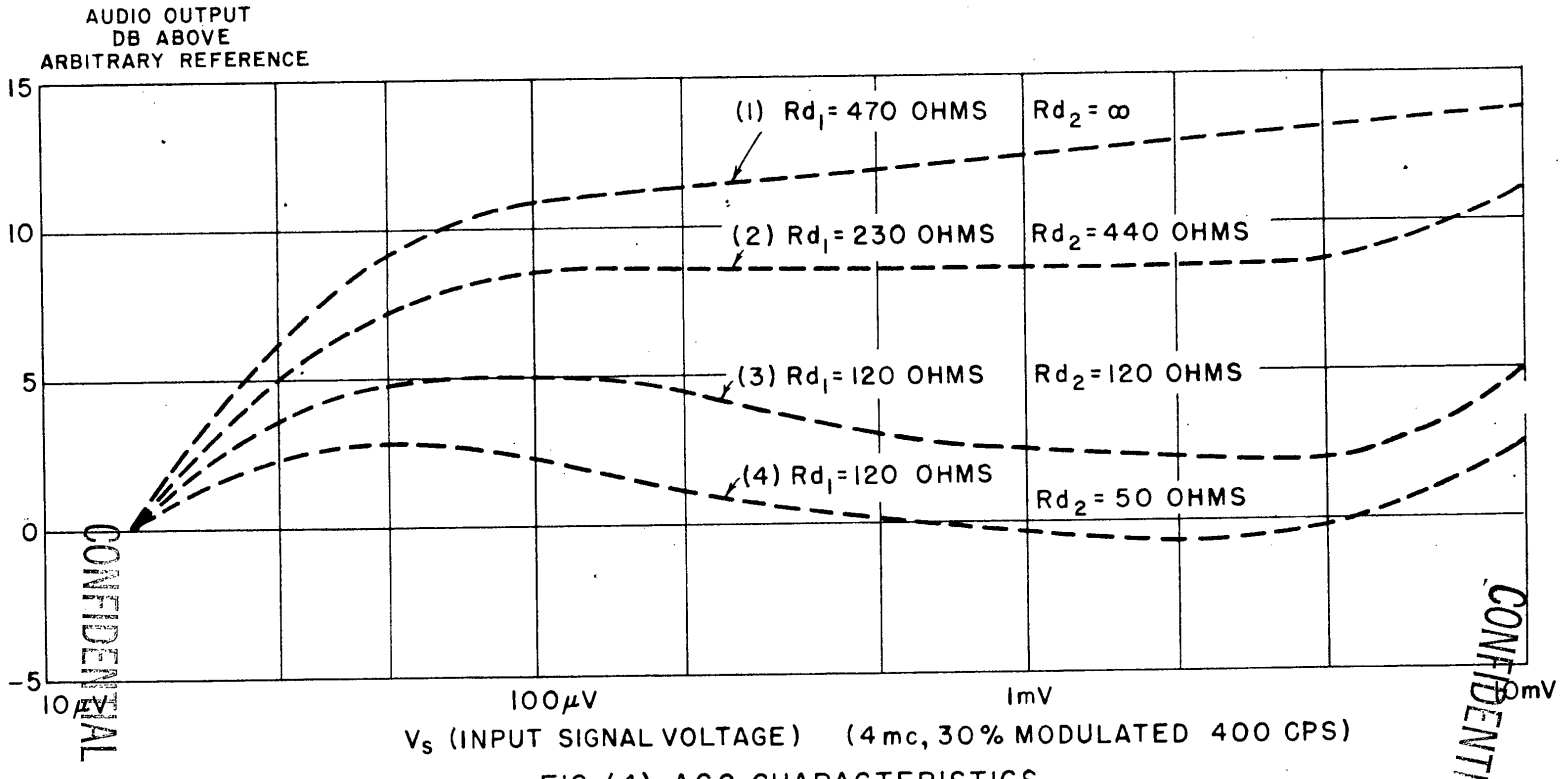


FIG. (4) AGC CHARACTERISTICS